AMERICAN BLAST-FURNACE WORK.

THE history of the gradual development of blast-furnace working in America, culminating in the production of 2500 tons of pig-iron in the short space of one week, with an expenditure of only 16·8 cwt. of coke per ton of iron, is interesting, especially if compared with ours, where the largest make has not exceeded 1000 tons, with an expenditure of about 1 ton of coke. It is difficult to find satisfactory reasons for this great difference, and the members of the Iron and Steel Institute may well have been astonished at the results laid before them.

It is stated that the first good results were obtained by breaking away from the traditional practice of regulating the quantity of blast or air by the pressure-gauge, and noting instead the number of revolutions made by the blowing engine; probably it would have been better still if some means had been devised of registering the flow of waste gas issuing from the furnace-mouth.

The new era in the manufacture began in 1880, and is divided into three periods:—(1) Old practice—air supply limited, slow driving. (2) Air in excess, excessive driving, attended with a greater output of iron, but increased consumption of coke. (3) Moderate supply of air, rapid driving, great output of iron with decreased consumption of coke. The best results were obtained with air at a pressure of 9 pounds heated to 1100°, blown in at the rate of 25,000 cubic feet per minute, furnace 18,200 cubic feet capacity; a greater quantity, 30,000 cubic feet, proving too much, whilst with less the make of iron diminished. This furnace produced 10,035 tons of iron in one month, with an expenditure of 1834 pounds of coke; the average ratio of CO to CO_2 being 40 per cent. as against about 48 to 50 in this country. Altogether, the volume of air was increased from 16,000 cubic feet "old practice," to 25,000 per minute with improved results. Ultimately it is probable that 300,000 tons of iron may be produced in three years without repairs.

Some of our most prominent metallurgists took part in the discussion on Mr. Gayley's report, and it soon became evident that some long-cherished ideas and formulæ were open to question. One eminent authority was of opinion, however, that on the whole the utilization of fuel, as shown by analysis, was in favour of English practice; although the actual quantity of fuel burnt to CO_2 was 5·97 as against 4·99 cwt. in Pittsburg, accounting for the difference by pointing out the variations in the appropriation of the heat-units or calories under the various items. It was also remarked that the Pittsburg ore was much richer in iron than the English, the latter fusing 28 cwt. of slag as against 10·71 in the former. The loss of heat due to radiation, &c., and in the waste gases, was also less, and these combined causes might be said to account for the remarkable saving.

English metallurgists and engineers were not unanimous in their approval of the new system; such methods might not after all be better than the older and slower processes practised in this country; an expensive array of air-heating stoves, blast engines, boilers, &c., were required, entailing considerable outlay, possibly exceeding the margin of profit. On the other hand, it was contended that the greater output of iron and the saving in fuel, amounting to £24,000 per annum, would more than cover additional expense, and would be sufficient for relining and repairs of the furnace and accessories three or four times over. Fewer furnaces would suffice, and it would be easier and less expensive to manage, say, two furnaces, than four or more. A well-known authority declared in favour of large makes, coupled with rapid driving, but confessed that after all it was not clear where the advantages lay as regards the plant, working, and final results.

The most suitable form of furnace was discussed, but nothing very definite seems to have been said, beyond the general admission that the form facilitating the unchecked free descent of the ores, &c., was most suitable; a large hearth or crucible was also desirable. The equal distribution of the ascending reducing hot gases was not thoroughly discussed, although it is obvious that unequal distribution of the hot gases must correspond to a like varying reduction and heating of the ores, &c., charged. According to Dr. Percy, the equal distribution of the gases, &c., is of the utmost importance, and in his work a furnace is figured, giving the form of furnace most suitable for general uses; he states that, unless the interior parts, from the mouth downwards, are not properly proportioned, the regular production of iron of uniform quality cannot be insured.

It is submitted that the able discussion which has just been summarized, although accounting for a good deal, is still not so satisfactory as might be. The scientific researches on the *rationale* of the chemical reactions occurring in the blast-furnace, may now be termed complete. We can now determine exactly the chemical reactions of the gases passing through, as also the relative distribution of the calories which a given weight of carbon will produce when burnt to carbonic oxide in the furnace. So far, this seems satisfactory; but one pound of carbon, when burnt in the calorimeter, always gives the same number of calories, *i.e.* number of pounds of water heated 1°, "this is all." It is, however, well known that its combustion may be so regulated as to barely suffice for the fusion of a metal like lead; and with the same fuel a temperature may be attained equalling the fusion-point of the softest steel.

Temperature or heat-intensity may play an important part in blast-furnace work. Iron cannot be properly melted below a temperature well above its fusion point, and unless the fuel is burnt under well-understood conditions, *i.e.* very rapidly, it often occurs in practice that fuel is so slowly burnt as to barely suffice for fusion. Fusion is unduly prolonged, and obviously fuel is wasted, for the simple reason that heat-intensity is proportionate to the rate at which it is consumed.

Economical work depends entirely on the difference in temperature betwixt the heating medium and the heated body; and it follows, as the temperature of the furnace flame and gases approximates to that of the metal heated, considerably less heat is absorbed; finally, when the temperature of the metal approximates closely to that of the flame, the heat absorption becomes nearly inappreciable; thus fusion may be unduly prolonged. This final stage may be termed the critical point, sharply dividing the economical use of fuel from the reverse.[1]

The importance of maintaining the temperature at the end of the process of fusion cannot well be over-estimated: a few hundred degrees more or less makes all the difference.[2] Apparently sufficient attention has not been paid to this in blast-furnace work, although it is plain that as regards fusion of the iron and slag, the same law is applicable as when simply fusing iron in ordinary melting-furnaces.

The delivery of large quantities of air at a high pressure through many large openings (technically the *tuyères*), as practised in America, and the consequent rapid consumption of coke, must necessarily raise the heat-intensity (temperature) much above that of furnaces supplied with only a limited quantity of air, and it follows that, in the latter, iron, &c., is fused slowly, thus entailing a greater consumption of coke.

Concurrently with rapid melting, it is self-evident that the furnace drives faster, for it is obvious that the rate of descent of the materials charged is governed by the more or less rapid fusion of iron and the accompanying consumption of fuel. It is pretty generally admitted that rapid driving should be avoided, on the reasonable assumption that time is required for the complete reduction of the ore by the ascending gases. Yet in America only 16·8 cwt. of coke per ton of iron has been consumed in conjunction with rapid driving; but possibly temperature plays an important part throughout the whole smelting process. The law of heat exchanges previously discussed cannot be evaded. We will assume that the temperature at the *tuyères* in one furnace is 500° higher than in another; it follows that the comparatively cool descending materials absorb in a similar ratio, or more plainly a greater percentage of the total heat is utilized in the former than in the latter instance. It is, therefore, not so surprising that the waste gases leave the high temperature furnace at the comparatively low heat of 340°.

It would appear that, on the whole, sufficient attention has not been directed here to the absolute weight or volume of air used per unit of time with its consequent effects, and it may be ques-

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[1] "When iron has attained a temperature of 2500°, it will, when exposed to a heat-intensity of 3200°, absorb less than $\frac{1}{11}$ of this, and when iron is receiving the last 100° requisite to bring it up to the welding-heat of 3200°, the temperature of the furnace being 3300°, only $\frac{1}{34}$ will enter the iron, the remaining $\frac{33}{34}$ being wasted. By raising the temperature to 3700°, $\frac{1}{16}$ instead of $\frac{1}{34}$ will be utilized, thus exhibiting the fact that an addition of temperature of only $\frac{1}{8}$ increases the efficiency of the furnace fourfold."—*Prideau.*

[2] Cause of the remarkable saving of fuel effected by hot blast (Percy, "Metallurgy," p. 425) "It is therefore plain that the mere quantity of heat, *i.e.* the number of units of heat evolved can have little to do with the matter. This being admitted, the inevitable conclusion is that calorific intensity must be concerned, and that the temperature of what may be designated the most active part of the furnace must be higher in the case of hot blast than in the case of cold blast."—*Percy.*

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tioned whether as a general rule in this country the area of the air or blast-delivery pipes has been correspondingly enlarged in due proportion to the increased air temperature, often over 1000°, now not uncommon since the introduction of the modern brick-heating stoves. Surely with air expanded to nearly four times its normal volume at 60°, the ordinary blast pipes should be correspondingly enlarged, coupled also with a higher blast pressure. Thus it may be, when using highly heated air, the absolute weight of air (oxygen) supplied may not be properly proportioned to the weight of coke charged, greater or less; and if this be true, it is not surprising that many blast-furnace managers have condemned the use of superheated air; it seems just possible that coke may be charged in excess of the air supply, or *vice versâ*. In America they appear, "by dint of sheer practice," to have somehow realized this; they have even gone further, and ascertained that it is quite possible to deliver too much air. It seems, on the whole, that their superior practice may partly, at least, be explained on the probability that heat-intensity—in other words, temperature expressed in C. or F. degrees—plays its part; and that calculations based on heat-units alone, undoubtedly useful and necessary as they are, have only a limited application.

THE ZOOLOGY AND BOTANY OF THE WEST INDIES.[1]

THIS Committee was appointed in 1887, and reappointed in 1888 and 1889.

During the past year chief attention has been directed to the exploration of the island of St. Vincent, and two collectors have been maintained in that island at the expense of Mr. F. Du Cane Godman, who has kindly assisted the Committee in this manner in order that the funds at its disposal may be chiefly applied to the remuneration of contributors, to whom would be referred the large collections in zoology, already amounting in Insecta alone to about 3000 species. The plants have been determined at the Herbarium of the Royal Gardens, Kew, and are nearly completed to date. A separate report on the collections in zoology and botany is given below.

It is proposed by the Committee to accept the services of Mr. R. V. Sherring, F.L.S., to make collections in botany in the island of Grenada during the coming winter. Mr. Sherring is well acquainted with the West Indies, and has already made collections there, and added several new species of ferns to the flora of Jamaica.

Zoology.

Since the last Report of the Committee three collections have been received from Mr. H. H. Smith, the collector sent by Mr. Godman to the island of St Vincent. These collections include a complete set of the birds already known to inhabit the island, and a few additional species; a small number of reptiles and crustaceans; a large series of spiders; and a great many Insecta; these last amounting, it is thought, to about 3000 species.

In 1889, Colonel Feilden paid a visit to the island of Dominica for the purpose of ascertaining whether the Diablotin (*Estrelata hæsitata*) has become extinct there, as has been reported by Ober. The account of his expedition that Colonel Feilden has published leaves little doubt that this is the case.

Although Mr. Smith has now been occupied about a year and a half in the exploration of the island of St. Vincent, Mr. Godman has decided, with the concurrence of the Committee, that he shall still continue there, as it is not yet clear that the more inaccessible portions of the island have been sufficiently examined.

Mr. Godman has agreed to give a first set of the zoological specimens obtained by his collector to the National Collection contained in the British Museum, and the Committee is at present endeavouring to find competent zoologists to work out the extensive series of insects and spiders that has been obtained.

Commander Markham, R.N., contributed some specimens in zoology collected by him in the Leeward and Windward Islands of the West Indies, and Captain Hellard, R.E., local secretary to the Committee at St. Lucia, has recently forwarded four boxes of Lepidoptera collected by him in that island.

Botany.

A small collection of plants, numbering 143 specimens, was received from Mr. J. J. Walsh, R.N. This collection included plants from Dominica, St. Martin's, St. Eustatius, St. Kitts, St. Lucia, and Grenada. Most of the plants consisted of common West Indian species, presumably such as would be met with in the more accessible spots in the various places visited.

The remainder of the plants collected by Mr. Ramage at St. Lucia have been determined. Of 84 species sent, 62 have been fully determined. The others include several that are apparently new. They are wholly woody or forest plants, and comprise *Sloanea* sp., *Picramnia* sp., *Xanthoxylum* sp., *Bursera* sp., *Miconia* sp., *Cyphanthus* sp., *Lucuma* sp., *Siparuna* sp., *Helosis* sp., *Gymnanthes* sp., and *Cyclanthus* sp. In one or two cases the material is hardly sufficient for satisfactory determination. Two of the above undetermined species have also been collected in Dominica and one in Martinique by earlier collectors.

Three collections have been received from St. Vincent through Mr. Godman, viz. in September 1889, and March and August 1890. The first collection has been determined at Kew by Mr. Rolfe as far as the end of the *Polypetalæ*. Of the 252 numbers (to this point) 47 were duplicates; thus 205 species were represented. All but about 9 of these were fully determined, the great bulk consisting of widely diffused West Indian plants; 128, or more than half, appear to have been recorded from the island before.

The undetermined specimens are *Traitinickia* sp., *Stigmaphyllon* sp., *Trichilia* sp., *Meliosma* sp., *Lysiloma* sp., *Moquilea* sp., a species of *Eugenia* obtained by Hahn in Martinique, and two species, probably of *Pithecolobium*, of which the material was somewhat inadequate. Several of these appear to be new, the first-named being specially interesting, because the genus was hitherto only known from Guiana and Brazil. In addition to this may be mentioned that several species of somewhat restricted distribution in the West Indies, more especially from Martinique and St. Lucia, have also been found in St. Vincent.

The second collection from St. Vincent consisted for the most part of ferns. Mr. J. G. Baker has fully worked out these. They include 133 species and well-marked varieties, three of which are new. The specimens are in excellent state of preservation, and it is probable that we have amongst them nearly all the fern flora of the island, both of the mountains and the lowlands.

As our knowledge of the fern flora of St. Vincent may be now regarded as practically exhaustive, it seems probable that some species hitherto attributed to the island, on the authority of specimens collected by the Rev. Lansdowne Guilding, really belong to other islands. This error has arisen from want of precision in exactly localizing the specimens, a practice the importance of which was hardly recognized at the time they were collected.

The collections received in August last contain three additional species of ferns, making the total number collected by Messrs. Smith 136. The added species are *Dicksonia cicutaria*, Sw., *Davallia aculeata*, Sw., *Cheilanthes radiata*, R. Br. In addition there are 389 numbers of flowering plants, and 3 palms. These will be determined later.

The Committee would again draw particular attention to the botanical and zoological bibliography of the Lesser Antilles prepared under its direction, and published as an appendix to the Report for 1888. This bibliography has been widely distributed in the West Indies and in Europe, and has proved of considerable service in carrying out the objects for which the Committee was appointed.

The Committee recommend their reappointment, and that a grant of £100 be placed at their disposal.

THE HILL ARRIANS OF INDIA.

AT a recent meeting of the Anthropological Society of Bombay, a paper was read by the Rev. A. F. Painter on the Hill Arrians, who live along the slopes of the Western Ghats in the Native State of Travancore, between Quilon in

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[1] Third Report of the B.A. Committee, consisting of Prof. Flower (Chairman), Mr. D. Morris (Secretary), Mr. Carruthers, Dr. Sclater, Mr. Thiselton-Dyer, Dr. Sharp, Mr. F. Du Cane Godman, Prof. Newton, Dr Günther, and Colonel Feilden, appointed for the purpose of reporting on the present state of our knowledge of the Zoology and Botany of the West India Islands, and taking steps to investigate ascertained deficiencies in the Fauna and Flora.

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